

laid upon the importance of the work of G. I. Taylor¹ in eddy-motion in the atmosphere, and of the value of his coefficient of "eddy conductivity" in meteorological work. Frequent references are made to the work of Dines and Dobson with pilot balloons. In the concluding chapters he deals with the "revolving fluid of the atmosphere." The Meteorological Office has published² Sir Napier Shaw's previous work along this line, so that the material presented in the latter portion of the "manual" is a résumé of that to be found in the memoir.³
—C. L. M.

THE TRAVELING CYCLONE.

By the late LORD RAYLEIGH.

(The London, Edinburgh, and Dublin, Phil. Mag., and Jour. of Sci., 6th Ser., No. 225, September, 1919, pp. 420-424.)

One of the most important questions in meteorology is the constitution of the traveling cyclone, for cyclones usually travel. Sir N. Shaw⁴ says that "a velocity of 20 meters/second (44 miles per hour) for the center of a cyclonic depression is large but not unknown; a velocity of less than 10 meters/second may be regarded as smaller than the average. A tropical revolving storm usually travels at about 4 meters/second." He treats in detail the comparatively simple case where the motion (relative to the ground) is that of a solid body, whether a simple rotation, or such a rotation combined with a uniform translation; and he draws important conclusions which must find approximate application to traveling cyclones in general. One objection to regarding this case as typical is that, unless the rotating area is infinite, a discontinuity is involved at the distance from the center where it terminates. A more general treatment is desirable, which shall allow us to suppose a gradual falling off of rotation as the distance from the center increases; and I propose to take up the general problem in two dimensions, starting from the usual Eulerian equations as referred to uniformly rotating axes.⁵

Sir J. Larmor has added to Rayleigh's incomplete article a paraphrase, which closes as follows: "In any case, internal viscosity is negligible in meteorological problems. It is the friction against land or ocean, introducing turbulence which spreads upward, that disturbs and ultimately destroys the cyclonic system; and the high degree of permanence of the type of motion seems to permit that also to be left out of account. As remarked in the postscript, the changes of pressure arising from convection involve changes of density, which will modify the motion but perhaps slightly. There does not seem to be definite discordance with Dr. Jeffreys's detailed discussion."

ON TRAVELING ATMOSPHERIC DISTURBANCES.⁶

By HAROLD JEFFREYS.

[Author's summary.]

The geostrophic⁷ relation between the wind and the surface pressure gradients is incapable of accounting for any variation whatever with time in the pressure distribution.

¹ Eddy Motion in the Atmosphere, *Phil. Trans.*, 1915, vol. 215, pp. 1-26.
² Skin Friction of the Wind on the Earth's Surface, *Proc. Roy. Soc. Ser. A*, 1916, vol. 92, pp. 196-199.

³ Phenomena Connected with Turbulence in the Lower Atmosphere, *idem*, 1918, vol. 91, pp. 137-155.

⁴ A discussion of these papers by Mr. Erie R. Miller will appear in the October issue of the *Review*.

⁵ Sir Napier Shaw: The Travel of Circular Depressions and Tornadoes and the Relation of Pressure to Wind for Circular Isobars *Met. Off. Geophysical Memoirs*, No. 12-1918.

⁶ See *Review*, p. 643, above.

⁷ Manual of Meteorology, Part IV, p. 121, Cambridge, 1919.

⁸ Lamb's *Hydrodynamics*, par. 207, 1916.

⁹ *Phil. Mag.*, London, January, 1919, Ser. 6, 27: 1-8. See also *Sci. Abs.*, March, 1919, pp. 92-93.

¹⁰ *Geostrophic*.—"Let us call the one [component] due to the rotation of the earth the 'geostrophic' component, and the other due to the curvature of the path the 'cyclotrophic' component."—*Gr. Brit. Met. Office, handbook, Weather Map and Glossary, London, 1918, p. 125.*

All changes in this arise from those terms in the equations of motion that are neglected when the geostrophic relation is assumed. When these terms, which depend on the squares and differential coefficients of the velocities, are taken into account, it is found that an asymmetrical cyclone can move. It seems, however, from the low speed of travel of these depressions, that a simple superposition of a general pressure gradient on a rotating system must be compensated internally in some way, so as to reduce the asymmetry introduced. Thus the remarkable circularity of the isobars in a cyclone is seen to be a condition of its slow movement. It is indicated that the cyclone itself is a very special type of disturbance, in which the pressure, temperature, and velocity are so distributed as to make the wave tending to readjust it travel with extreme slowness; other types of disturbance spread out much more rapidly (with velocities of the order of that of sound) and are dissipated, and this fact is probably the reason why, [that] of all the irregularities possible, the cyclone is the most conspicuous, other forms dissipating before they can be observed.

CHARACTERISTICS OF THE FREE ATMOSPHERE.¹

By W. H. DINES, F. R. S.

(Abstract.)

SYNOPSIS.—"This report was prepared in 1916, but on account of the war it was not then published." The subject is discussed under the following headings:

1. Methods and places of observation.
2. Amount and reliability of the material.
3. Mean temperatures and gradients.
4. The seasonal variation.
5. The daily temperature range.
6. The humidity.
7. The troposphere and stratosphere.
8. Pressure and density.
9. The motion of the free atmosphere.
10. Statistical data.
11. The connection between pressure and temperature.
12. The vertical temperature gradient and the value of H_p .

Appendix. The standard deviations of the density of the air from 1 to 13 kilometers, and the frequency of occurrence of deviations of given magnitude.

In general the paper deals with data and conclusions that had already been presented elsewhere, but they are here brought together into concise form, together with some of the more recent results. The reader is thus enabled to gain a comprehensive idea of the whole subject without having to consult several separate papers that have appeared from time to time in various publications.

1. *Methods and places of observation.*—For the most part the discussion is based upon results obtained in different parts of Europe, although equatorial and Canadian values are given in some of the tables and are briefly referred to in the text. In all cases the data were obtained by means of sounding and pilot balloons.

2. *Amount and reliability of the material.*—Practically 90 per cent of the balloons sent up in continental Europe are recovered; but in England, owing to the proximity of the sea, the loss averages about 35 per cent. Different sizes of balloons and various types of meteorographs are used, but the mean results of 10 years' work are practically identical. Instrumental and reduction errors are evidently not large, inasmuch as the agreement between near-by stations and between successive observations at the same station is close. All the evidence indicates that the probable error for temperature does not exceed 1° C.; for pressure it is about 4 mb. The effect of the latter in the determination of altitude in the lower levels is inappreciable, but at great heights, e.g., 20 kilometers, an error of 2 kilometers is possible. These errors are largely

¹ *Geophysical Memoirs* No. 13, Meteorological Office, London, 1919. M. O. 220c, pp. 47-76.

eliminated in the means of a larger number of observations, but, on the other hand, an annual mean, if based on a limited number of records, may be in error a similar amount, since some of the observations themselves may have been made under exceptional conditions.

3. *Mean temperatures and gradients.*—Tables giving mean temperature and gradients show very conclusively the latitudinal variations, viz, lower temperature of the northern stations up to 8 or 10 kilometers and higher temperature above those heights. The following values, taken from the tables, illustrate this variation fairly well, temperatures being expressed in degrees Centigrade absolute:

Height, kilometers.	Petro- grad (66° N.).	England, S. E. (52° N.).	Pavia, Italy (45° N.).	Canada (43° N.).	Equa- torial.
14.....	223.5	218.9	217.7	212.5	203
13.....	23.4	18.7	16.4	14.0	11
12.....	20.7	18.8	16.1	16.2	19
11.....	20.0	19.6	18.5	19.3	27
10.....	21.3	22.2	22.7	23.2	35
9.....	24.4	27.5	27.3	29.3	43
8.....	29.8	33.6	33.9	35.9	51
7.....	37.1	40.7	41.2	43.5	58
6.....	43.3	47.8	49.4	50.9	65
5.....	49.8	54.8	56.2	57.7	72
4.....	55.7	61.7	62.9	64.1	79
3.....	61.3	67.7	69.2	69.6	85
2.....	66.7	73.2	75.1	74.8	90
1.....	71.0	78.0	80.7	78.3	95
0.....	76.1	(83.0)	.....	.....	300

In Europe the temperatures do not change on the average above 14 kilometers, but those in the equatorial regions continue to decrease to 17 or 18 kilometers, reaching at those heights a value of about 193° A.

4. *The seasonal variation.*—In determining the monthly mean values for England it was thought best, owing to the small number of observations in each month, to smooth the values by harmonic analysis. It is not certain that the temperatures in the upper air follow the course prescribed by a single sine curve, but until many more observations are available it is quite impossible to compute the amplitudes of the second, third, etc., terms. When smoothed and tabulated, the results show that the annual range extends to 8 or 9 kilometers, but diminishes to about half its surface value at 12 kilometers and above. The extremes occur considerably later with increasing height up to about 11 kilometers but fall back rapidly, the minimum at 13 kilometers and higher levels in Europe occurring near the beginning of the year. In Canada the minimum appears to occur in summer, although observations are not sufficiently numerous to make this a certainty. Attention is called to the probability that in Europe the indicated annual range is greater than the true range, owing to the effect of insolation on the meteorographs.

5. *The daily temperature range.*—Not much can be said with respect to the diurnal range, but in general the surface type decreases rapidly with height and practically ceases between 1 and 2 kilometers. At higher levels a reversal is shown by observations at Blue Hill and Mount Weather. Investigations elsewhere indicate very small amplitudes and no certainty as to the times of the maximum and minimum.

6. *The humidity.*—Humidity in general increases from the surface to the lower cloud level, about 1 to 2 kilometers, and decreases above. Inversions of temperature are usually accompanied by low relative humidity. Low humidity is likewise shown at great heights, but the effect of extreme cold on the hair hygrometer renders such observations of doubtful value.

7. *The troposphere and stratosphere.*—Mean temperatures erroneously indicate a gradual transition from the troposphere to the stratosphere, but in individual observations there is usually an abrupt break. Occasionally, however, the gradient ceases gradually and in such cases the height of the base of the stratosphere, H_c or "tropopause," is taken as that above which the change is not greater than 2° C. per kilometer. In the troposphere inversions are frequent near the surface, especially on clear nights and during the entire day in winter anticyclonic weather. They also occur at the upper surface of cloud layers, but are rarely found between 5 and 10 kilometers. In the stratosphere the conditions are practically isothermal. The value of H_c varies in Europe with cyclonic and anticyclonic weather from about 8 to 13 kilometers. There is also a distinct variation with latitude, as shown in the following examples: Petrograd, 9.6 kilometers; England, 10.6; Italy, 11.0; and southern Canada, 11.7. At all places the height is somewhat greater in summer than in winter, although the mean difference is probably less than 1 kilometer.

8. *Pressure and density.*—The author gives tables containing mean annual pressures at different altitudes for a number of places in Europe and for Canada and the Equator; and mean monthly pressures at different heights over England. These pressures have not been directly observed for the various altitudes but have been computed by the hypsometric formula, the temperature correction being determined from the observed mean values. At intermediate altitudes there is a marked variation of mean pressure with latitude, amounting in the Temperate Zone to nearly 1 mb. per degree, the values decreasing, of course, from south to north. At the surface the change with latitude is much smaller. Above 12 kilometers it again diminishes and at 18 to 20 kilometers there is practically no difference between the mean pressure at the Equator and that at latitude 60° N. at least. The annual pressure range is largest at 7 to 10 kilometers, amounting in England to about 18 mb., highest values of course occurring in summer. At 1 kilometer the range is about 6, and at 15 kilometers about 9 mb. A table of densities is also given. These have not been corrected for water vapor, but the error is small up to 1 or 2 kilometers and negligible at higher levels. Mean temperatures, pressures, and densities for England (S. E.), Europe, Canada, and the Equator are contained in the following table:

Height in kilo- meters.	England (S. E.)			Europe.			Canada.			Equator.		
	T.	P.	D.	T.	P.	D.	T.	P.	D.	T.	P.	D.
	°A	mb.	g./m. ³	°A	mb.	g./m. ³	°A	mb.	g./m. ³	°A	mb.	g./m. ³
20.....	219	55	87	219	55	87	214	54	88	193	53	91
19.....	219	64	102	219	64	102	215	63	102	193	63	113
18.....	219	75	119	219	75	119	214	74	121	193	75	135
17.....	219	88	139	219	88	139	211	87	144	193	90	162
16.....	219	102	162	219	102	162	211	102	169	195	107	191
15.....	219	120	191	219	120	191	211	120	198	198	128	225
14.....	219	140	223	219	140	223	212	142	233	203	152	261
13.....	219	164	261	219	164	261	214	167	268	211	178	294
12.....	219	192	305	218	192	307	216	195	314	219	209	331
11.....	220	224	355	219	225	358	219	228	365	227	244	374
10.....	222	261	409	222	262	411	223	266	415	235	283	419
9.....	228	303	463	227	305	467	229	309	470	243	327	469
8.....	234	352	524	233	353	528	236	358	528	251	376	522
7.....	241	407	589	241	408	590	243	413	592	258	430	581
6.....	248	469	658	248	470	661	251	475	662	265	491	645
5.....	255	538	735	255	538	735	258	543	733	272	558	714
4.....	262	615	819	261	614	819	261	618	815	279	632	789
3.....	268	699	909	267	699	913	270	703	905	285	713	871
2.....	273	795	1,011	272	794	1,017	275	798	1,011	290	803	968
1.....	278	900	1,128	277	899	1,128	278	903	1,134	295	908	1,067
0.....	282	1,014	1,253	281	1,011	1,258	282	1,017	1,258	300	1,013	1,174

9. *The motion of the free atmosphere.*—A consideration of the motion of the free atmosphere, as indicated by observations with kites and balloons and by the motion of clouds leads to the following conclusions so far as the temperate zones are concerned:

(1) The wind on the whole increases with increasing height up to the limit of the troposphere, and it falls off rapidly as the common boundary of the stratosphere and troposphere is passed.

(2) The component of the wind from west to east shows a systematic increase with height, until it begins to fall off in the stratosphere, but the south-to-north component shows no such increase.

(3) The geostrophic [gradient] wind is usually reached at a small height, less—that is, than 1 kilometer; above that the wind still veers somewhat as a rule, but at great heights the winds can not be inferred with much certainty from the surface distribution of pressure.

(4) Strong winds from some point between north and south on the western side are occasionally met with at great heights blowing away from the upper part of cyclonic areas.

The first two conclusions are in accord with pressure observations, viz., a decided south to north decrease at intermediate altitudes and practically no change at great heights, 18 to 20 kilometers. The third conclusion is to be expected, since friction due to topographic interferences largely disappears a short distance above the earth's surface. Nothing definite can as yet be said as to wind conditions in the equatorial regions.

10. *Statistical data.*—The close connection existing between certain elements in the free air has led the author to study statistically all available data for Europe and to compute correlation coefficients between the following quantities:

- P_0 , barometric pressure at M. S. L.
 P_1 , barometric pressure at 1 kilometer.
 P_n , barometric pressure at n kilometers.
 T_0 , temperature at the surface.
 T_1 , temperature at 1 kilometer.
 T_n , temperature at n kilometers.
 H_c , thickness of the troposphere, or the base of the stratosphere.
 T_{H_c} , temperature at H_c .
 W , west—east component in the wind, west being positive.
 S , south—north component in the wind, south being positive.
 G_w , west—east component of gradient wind at surface.
 G_n , south—north component of gradient wind at surface.
 T_m , mean temperature from 1 to 9 kilometers.
 V , total water vapor contents of the atmosphere.
 T_{0-4} , mean temperature up to 4 kilometers.

The correlation coefficients are given in the following table:

	P_0	P_1	T_m	H_c	T_0	V	T_0	T_{0-4}	T_1	T_2	W	S	G_w	G_n
P_0	1.00													
P_1	0.68	1.00												
T_m	0.47	0.95	1.00											
H_c	0.68	0.84	0.79	1.00										
T_0	0.52	0.47	0.37	0.68	1.00									
V	0.08	0.28	0.30	0.39	0.30	1.00								
T_{0-4}	0.34	0.82	0.64	0.73	0.66	0.73	1.00							
T_1	0.47	0.82	0.64	0.73	0.66	0.73	0.73	1.00						
T_2	0.47	0.82	0.64	0.73	0.66	0.73	0.73	0.73	1.00					
W	0.08	0.28	0.30	0.39	0.30	0.30	0.30	0.30	0.30	1.00				
S	0.08	0.28	0.30	0.39	0.30	0.30	0.30	0.30	0.30	0.30	1.00			
G_w	0.08	0.28	0.30	0.39	0.30	0.30	0.30	0.30	0.30	0.30	0.30	1.00		
G_n	0.08	0.28	0.30	0.39	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	1.00	

In addition to the above, the following values which can not be conveniently placed in the table are given:

	P_0 and	T_{H_c}	
T_0	0.28	T_1	0.73
T_1	0.60	T_2	0.74
T_2	0.68	T_3	0.82
		T_4	0.82

	T_0 and P_0	T_1 and P_1	T_2 and P_2	T_3 and P_3	T_4 and P_4	T_5 and P_5	T_6 and P_6	T_7 and P_7	T_8 and P_8	T_9 and P_9	T_{10} and P_{10}	T_{11} and P_{11}	T_{12} and P_{12}	T_{13} and P_{13}
Jan.-Mar.	-0.02	0.54	0.82	0.79	0.86	0.85	0.84	0.87	0.91	0.81	0.35	-0.32	-0.38	-0.37
Apr.-June	.11	.28	.49	.79	.89	.89	.92	.87	.81	.45	.20	-.12	-.24	-.01
July-Sept.	-.02	.31	.56	.72	.75	.81	.83	.87	.88	.43	-.08	-.41	-.41	-.19
Oct.-Dec.	.33	.56	.76	.77	.83	.87	.85	.86	.86	.78	.29	-.24	-.34	-.50
Means	.11	.42	.66	.77	.81	.85	.86	.86	.86	.71	.32	-.19	-.36	-.28

Also—Steepness of barometric gradient and H_c -0.22
 Barometric rise in past 12 hours and H_c -0.17

11. *The connection between pressure and temperature.*—The author points out that the probable errors in all these coefficients are small, inasmuch as in nearly every case more than 100 observations have been used. The values bring out very clearly the close connection between P_0 , H_c and the temperature at different levels except at the surface; also between P_0 and all temperatures except at the surface, and between pressure and temperature at the same levels between 4 and 8 kilometers. They show moreover that the lower strata are cold in a cyclone and warm in an anticyclone. "As the barometer falls the temperature of the air column from 1 to 9 kilometers falls also, the value of H_c decreases, and the temperature of the upper air from 11 to 20 kilometers rises. As the depression moves away and the barometer rises the lower air column rises in temperature, H_c increases, and the upper air column falls in temperature." Low pressure at the surface remains low, and high pressure at the surface remains high as compared with the normal, up to about 20 kilometers, but the pressure differences fall off from the ground upward, slightly from 2 to 9 kilometers, and rapidly above 10 kilometers. The cold air in the cyclone can not be accounted for by the wind circulation, since the temperature fall begins while the wind up to moderate heights at least is from a southerly direction; nor by radiation, because the observed change in temperature is altogether too great. It must be due then to dynamic cooling, caused to a small extent by the slightly lower pressure itself, but mostly by vertical circulation. That such circulation necessarily exists is evident from the crossing of the isobars by the surface winds. The process by which this cold air ascends is difficult of explanation, but it is shown that, whatever the cause, "this rule is a corollary that follows from the uniformity of pressure at 18 to 20 kilometers." This pressure equality necessitates a uniformity in the mean temperature of the air column from the surface to 20 kilometers in all parts of the earth and under all conditions of weather; and the data obtained show that this uniformity of mean temperature really exists. In other words, when the lower strata are cold, the upper strata are warm, and vice versa. This may explain the lower temperatures at great heights above Canada in summer than in winter, and the excessively low temperatures at high altitudes above the equator.

12. *The vertical temperature gradient and the value of H_c .*—The concluding section of the paper contains a discussion of the relationship between the temperature gradient and the value of H_c . The cause of the observed temperature gradient is ascribed in part to the mixing of the air by the winds, this mixing being balanced by the opposed effect of radiation, and in part to what may be called the "greenhouse effect," i. e., the transmission of solar radiation through the air and the absorption of terrestrial radiation by the air. Even then it is not plain why the vertical gradient ceases so abruptly. An inspection of the correlation coefficients already given shows a marked connection between H_c and P_0 and between H_c and T_m . By the method of partial correla-

tion it is found that H_c follows the changes of P_s with great accuracy, no matter what the variation of T_m may be; also that there is little connection between H_c and the water vapor. In other words, "if the air pressure at 9 kilometers is high, then H_c is large; and if the pressure is low, then H_c is small. It is certainly this

pressure that matters; other things are of trifling or of no importance in comparison."

An appendix contains a table, with brief introduction of seasonal standard deviations of temperature, pressure, and air density in England (S. E.) from the surface to 13 kilometers.—*W. R. Gregg.*

VERTICAL TEMPERATURE DISTRIBUTION IN THE LOWEST 5 KILOMETERS OF CYCLONES AND ANTICYCLONES.

By WILLIS RAY GREGG, Meteorologist.

[Dated: Weather Bureau, Washington, October 30, 1919.]

It has been conclusively shown, not only in Mr. Dines' paper, a review of which is given above, but also in several others, that in Europe cyclones are colder than anticyclones at all altitudes in the troposphere, except at and near the earth's surface in winter. This condition is not indicated by observations made in the United States, and it is interesting to ascertain, if possible, the reasons for this difference in the two regions. First, though, it may not be amiss to inquire what has heretofore been the basis of classification whereby certain observations have been represented as having been made in cyclones or in anticyclones. Obviously, if the surface pressure has been the only guide, an entirely erroneous conclusion may have been reached, as a preponderance of observations in one quadrant of a cyclone or anticyclone would produce a result in no sense representative of the average conditions in the one system or the other, but rather those of that particular quadrant. Again, we occasionally have low-pressure¹ anticyclones and high-pressure¹ cyclones; if under such conditions the station pressure determined the classification we are likely to include many observations in one class which distinctly belong to the other. The question of the horizontal distance from the center to which the influence of a cyclone or an anticyclone may be said to extend is also a perplexing one. In general it is believed that the classification should be made from a careful inspection of the barometric distribution prevailing in each case, and that only such observations should be included as are well within the influence of the one system or the other, this determination being dependent, therefore, not only upon the station pressure itself, but also upon the character of the pressure gradient and upon the resultant wind conditions. Moreover, the observations should be as evenly distributed as possible among the various quadrants of the two systems, or, if this is impossible, the mean values in the quadrants should be taken, in order that equal weight may be given to each, for it is undoubtedly true, in this country at least, that the influence of a northerly or southerly component in the wind, characteristic of rising and falling pressure, respectively, upon air temperature is greater than that due to dynamic heating or cooling within the pressure systems themselves. This point will be referred to later.

In the table below are presented data based upon observations with kites at Mount Weather, Va., and Drexel, Nebr. The Mount Weather data are taken from the Bulletin of the Mount Weather Observatory, volume 6, part 4; those for Drexel have not yet been published. In all cases the classification has been made as indicated in the preceding paragraph. All quadrants are well represented at Drexel; not so well at Mount Weather, because of its location south of the storm tracks, thus making it

impossible to obtain many observations in the northern parts of cyclones. Quadrants are numbered as follows: 1, northeast; 2, northwest; 3, southwest; and 4, southeast.

TABLE 1.—Mean free air temperatures, °C., in cyclones and anticyclones at Mount Weather, Va.

Altitude above sea level (meters).	Cyclones.					Anticyclones.				
	1	2	3	4	Mean.	1	2	3	4	Mean.
SUMMER.										
526.....	22.8	20.6	20.9	20.5	21.2	18.1	23.0	20.3	18.9	20.1
1,000.....	19.9	17.3	18.0	17.8	18.2	15.3	19.3	16.7	15.6	16.7
2,000.....	14.7	11.3	11.5	11.5	12.2	10.5	13.2	11.5	10.9	11.5
3,000.....	.....	5.2	5.8	5.6	(6.3)	5.9	8.3	6.8	5.2	6.6
4,000.....	.....	-1.1	-3	-2.1	(-4)	1.3	.....	2.3	0.2	(1.9)
5,000.....	.....	-7.2	-6.9	.....	.....	-5.1	.....	.....	.....	.....
WINTER.										
526.....	-0.4	-1.6	2.3	2.5	0.7	-3.4	-1.1	-3.8	-3.2	-3.6
1,000.....	-1.3	-4.6	.....	3.1	-9	-5.7	-1.1	-3.1	-5.7	-3.9
2,000.....	-1.5	-6.3	.....	1.1	-3.6	-6.7	-2.4	-1.0	-6.0	-4.0
3,000.....	-7.4	-9.9	-10.8	.....	-8.6	-10.2	-6.6	-5.1	-10.2	-8.0
4,000.....	.....	-14.1	-15.9	-11.5	(-13.5)	-15.5	-12.0	-10.9	-15.1	-13.4
5,000.....	.....	.....	-20.0	.....	.....	-23.1	-17.6	-15.7	-24.2	-20.2

TABLE 2.—Mean free air temperatures, °C., in cyclones and anticyclones at Drexel, Nebr.

Altitude above sea level (meters).	Cyclones.					Anticyclones.				
	1	2	3	4	Mean.	1	2	3	4	Mean.
SUMMER.										
396.....	22.9	19.5	21.8	26.2	22.6	16.6	18.2	20.0	17.8	18.2
500.....	22.1	19.2	21.2	25.6	22.0	16.4	17.6	19.7	17.1	17.7
1,000.....	19.2	16.3	18.4	22.6	19.1	12.8	14.9	18.7	13.2	14.9
2,000.....	14.1	9.8	12.2	16.9	13.2	5.5	10.3	14.4	8.2	9.6
3,000.....	7.9	3.1	5.5	9.4	6.5	-1.1	4.5	8.1	3.3	3.7
4,000.....	.9	-2.2	-2.0	2.5	0.2	-3.8	-0.8	1.0	-1.7	-1.3
5,000.....	.....	.....	-9.4	-3.4	(-6.5)	.....	-6.6	.....	-7.9	(-7.1)
WINTER.										
396.....	-4.4	-7.4	-3.4	-1.6	-4.2	-11.2	-5.2	-7.3	-11.4	-8.8
500.....	-5.1	-8.0	-3.8	-1.0	-4.5	-11.3	-4.5	-7.7	-12.0	-8.9
1,000.....	-3.8	-9.2	-4.6	2.8	-3.7	-9.7	-2.6	-5.8	-12.4	-7.6
2,000.....	-4.3	-8.7	-5.7	1.9	-4.2	-10.7	-1.8	-4.1	-9.4	-6.5
3,000.....	-8.6	-12.7	-10.0	-3.7	-8.8	-14.8	-5.9	-7.3	-12.8	-10.2
4,000.....	-12.7	-16.6	.....	-9.8	-13.5	-19.4	-11.6	-11.2	-17.7	-15.0
5,000.....	.....	.....	.....	-15.3	(-19.1)	-27.1	-17.8	.....	-22.8	(-21.3)

An examination of these two tables shows that both in summer and in winter temperatures at and near the surface are lower in anticyclones than in cyclones, more decidedly so at Drexel than at Mount Weather. At higher levels there is little difference in the values at Mount Weather, and that slight difference is in favor of the "cold cyclone" theory; at Drexel the anticyclone still continues colder than the cyclone, but the difference

¹ Relative to normal, not relative to surrounding pressure.